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A novel approach to Edge Detection in Coloured Images by Genetic Algorithms & Neural Networks

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Abstract - The amount of processing that is required to be done on images can be reduced significantly by representing the images in the form of edges. The image edges include rich information that is very significant for obtaining the image characteristic by object recognition. Edge detection refers to the process of identifying and locating sharp discontinuities in an image. So, edge detection is a vital step in image analysis and it is the key of solving many complex problems. In this paper, we have proposed a new algorithm for edge detection in colored images using genetic algorithm and neural networks.

Keywords: Edge detection, Genetic algorithm, Neural Networks, Soft Computing

I. INTRODUCTION

In the past vast amount of work has been done in order to reduce the amount of information to be processed. Edge detection is one of the means of achieving this goal. Edge detection is the process of localizing pixel intensity transitions. The success of edge detection provides a good basis for the performance of higher level image processing tasks such as object recognition, target tracking and segmentation, since it reduces the amount of information to be processed over the years.[5]

The goal of edge detection is to mark the points in a digital image at which the luminous intensity changes sharply. For Computer vision and Image processing Systems to Interpret an Image, they first must be able to detect the edges of each object in the image.Edge representation of an image drastically reduces the amount of data to be processed, yet it retains important information about the shapes of objects in the scene. This description of an Image is easy to integrate into a large no of object recognition algorithms used in computer vision and other image processing applications. Edge detection produces an edge map that contains important information about the image.[1] The Memory space required for storage is relatively small, and the original image can be restored easily from its edge map. This method has proved both effective and powerful and is widely used in applications ranging from satellite imaging to medical radiology

Many methods have been proposed for edge detection.[3] Traditional edge detection techniques include Roberts, Prewitt, Sobel edge detectors.[4] These techniques doesn't show good result and faces many drawbacks. Then these were replaced by laplacian of Gaussian and Canny operators.[2] These used second order derivative operator which showed far better result than the first derivative operators.

The latest trend is to use soft computing techniques in order to find edges from the image. The soft computing techniques can be further divided into neural networks and fuzzy logic techniques. An addition to the research in finding edges from the image has been the use of genetic algorithm.

II. NOISE

Noise is considered to be any measurement that is not part of the phenomena of interest. Images are prone to different types of noises. Departure of ideal signal is generally referred to as noise. Noise arises as a result of unmodelled or unmodellable real signal. It is not part of the ideal signal and maybe caused by a wide range of sources, e.g.variation in the detector sensitivity, environmental variations, the discrete nature of radiation, transmission or quantization errors, etc. It is also possible to treat irrelevant scene details as if they are image noises, e.g., surface reflectance textures. The characteristics of noise depend on its source, as does the operator which reduces its effects. Many image processing packages contains operators to artificially add noise to an image. Deliberately corrupting an image with noise allows us to test the resistance of an image processing operator to noise and assess the performance of various noise filters.

Noise is generally grouped into two categories-independent noise and image data dependent noise

2.1 Image Data Independent Noise

This type of noise can be described by an additive noise

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model, where the recorded image, i(m,n) is the sum of the true image t(m, n) and the noise n(m, n):

i(m, n) = t(m, n) + n(m, n) σ(1)

The noise n(m,n) is often zero-mean and described by its variance . In fact, the impact of the noise on the image is often described by the signal to noise ratio (SNR), which may be given by

$$SNR = \frac{\sigma_t}{\sigma_n} = \sqrt{\frac{\sigma_i^2}{\sigma_n^2} - 1}$$

σ_t 2 and σ_i 2 are the variances of the true image and the recorded image, respectively. In many cases, additive noise is evenly distributed over frequency domain (white noise), whereas an image contains mostly low frequency information. Therefore, such a noise is dominant for high frequencies and is generally referred as Gaussian noise.

2.2 Image Data Dependent Noise

2.2.1 Poisson Noise

This type of noise is caused by the nonlinear response of the image detectors and recorders. Here the image data dependent term arises because detection and recording processes involve random electron emission having a Poisson distribution with a mean response value [11]. Since the mean and variance of a Poisson distribution are equal, the signal dependent term has a standard deviation if it is assumed that the noise has a unity variance.

2.2.2 Speckle Noise

Another common form of noise is data dropout noise commonly referred to as Speckle noise. This noise is, in fact, caused by errors in data transmission .The corrupted pixels are either set to the maximum value, which is something like a snow in image or have single bits flipped over.

2.2.3 Salt & Pepper Noise

This type of noise is also caused by errors in data transmission and is a special case of data dropout noise when in some cases single, single pixels are set alternatively to zero or to the maximum value, giving the image a salt and pepper like appearance [6].

III. CHALLENGES IN EDGE DETECTION

Extraction and segmentation has to deal with the following challenges:

(i) The changes in lighting condition

(ii) The background is dynamic

(iii) Luminance and geometrical features.

(iv) Noise volume has a great impact on shaping the edge

(v) Missing to detect existing edges

(vi) Detecting edges where it does not exist (false edge)

(vii) Position of the detected edge to be shifted from its true location (shifted edge or dislocated edge).

IV. DIFFERENT APPROACHES TO EDGE DETECTION

4.1 FUZZY BASED APPROACH

In 1990's, Sinha and Dougherty import fuzzy mathematics into morphology and forming fuzzy mathematical morphology. Image information is very complex, and image process may not be integrated or accurate, so fuzzy set theory used in image analysis can get better effect than other computing methods.

Dong Hu and Zianzhong Tian in their paper, they integrate the multi-directions characteristic of structure elements and image fuzzy characteristic into mathematical morphology and then detect the edges using mathematical morphology [6].Using fuzzy reasoning we can splendidly to enhance and detect edges. Fuzzy set theory is an approximation tool in modeling ambiguity or uncertainty and has been applied in image processing. Using some fuzzification function we can very well remove the noise efficiently from the given image.

George and Madan proposed fuzzy uncertainty measures for image processing in 1994.They showed that the fuzzy uncertainty measure is an approach for representing, processing and quantitatively evaluating the information in gray– tone images. A gray-tone image can be transformed into a fuzzy image by a Fuzzification function. Using Mathematical morphology operator's dilation and erosion, the fuzzification functions for positive edge uncertainty and negative edge uncertainty is defined. [7]

In the Fuzzy reasoning system, the rules are framed for edge localization and the rules are based on the following simple reasons. If a pixel (i, j) possesses larger edge uncertainty, this point should be preserved. Inversely, if it possesses smaller edge uncertainty, this point is regarded as a non-edge point.

Kanchan Deshmukh and Ganesh presented a neuro-fuzzy system to perform multilevel segmentation of color images in HSV colour space. It has two stages. In fist stage, the number of clusters of pixels with

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similar colour is found using FMMN clustering algorithm. In the second stage, neural network is used to find multiple objects in the image. [8]

ACISFMC system consists of a multilayer neural network which performs adaptive, multilevel thresholding of the color image. Fuzzy entropy is used as a tool to measure the error of the system. Adaptive threshold selection block is responsible to determine clusters and compute a multilevel sigmoid function of neurons. Neural network segmentation block does the actual segmentation based on the number of objects found out by adaptive threshold selection block.

The gradient and standard deviation computed at each pixel

4.2 NEURAL NETWORKS

Neural networks are nothing but the computer algorithms contend with how the way the information is processed in nervous system. Neural network diversifies from other artificial intelligence technique by means of the learning capacity.

Digital images are segmented by using neural networks in two step process. First step is pixel classification that depends on the value of the pixel which is part of a segment or not. Second step is edge detection that is the detection of all pixels on the borders between different homogeneous areas which is part of the edge or not [9]. Several neural networks are available in the literature for edge detection. The potential base function for digital image processing can be created using differential operators.

Generally, the neural network consists of three layers such as input layer, hidden layer and output layer as in the fig 1. Each layer consists of fixed number of neurons equal to the number of pixels in the image. The activation function of neuron is a multi-sigmoid. The major advantage of this technique is that, it does not require a priori information of the image. The number of objects in the image is found out automatically.

The feed-forward error-back propagation neural networks are trained with 3×3 to 11×11 inputs, 4 to 8 units in the single hidden layer, and a single output. All units used sigmoid activation functions. [10]. Hidden nodes, whose weights were regarded as a template, which is similar to any image filter (e.g.Kirsch or Sobel templates), and its Taylor series coefficients, were used to analyze the order of this template. Interesting results were found when some small neural networks edge detectors were trained with sharp edges whilst others were trained with sharp, blurred, and noisy variants of the same images. [11]

Each neuron is associated with a number for the neuron's activation. Each connection in the network is associated with a weight. The activation functions used for neuron outputs can be either linear or non-linear. The input signal is processed through input layer, hidden layer and output layer. The status of neurons in every layer affects status of neurons in the next layer only.

Neurons in the same layer do not have connection among themselves. The output of the nodes in one layer is transmitted to the nodes in another layer via links that amplify or inhibit such outputs through weighting factors. Except for the input layer nodes, the total input to each node is the sum of weighted outputs of the nodes in the previous layer. Each node is activated in accordance with the input to the node and the activation function of the node. Wavelet neural network (WNN) based on the wavelet transform theory, is a novel, multiresolution, hierarchical artificial neural network, which originally combines the good localization characteristics of the wavelet transform theory and the adaptive learning virtue of neural networks.The first module extracts the feature and the second one is WNN classifier which is used to locate the position of the edges. A three-layer neutral network is employed to determine the structure elements in the morphology method, so that the image can be smoothened and all probable edge points can be detected. Zernike moments operator is adopted to locate the edge to subpixel accuracy degree.The system consists of a neural network that performs the segmentation using multilevel thresholding activation function.

The main advantage of this method is that, it segments the color image without prior knowledge of the image. The threshold and target values are used to construct an activation function of neuron. The error of the system is calculated and back propagated to change the weights of neural network. This process continues until a minimum error is

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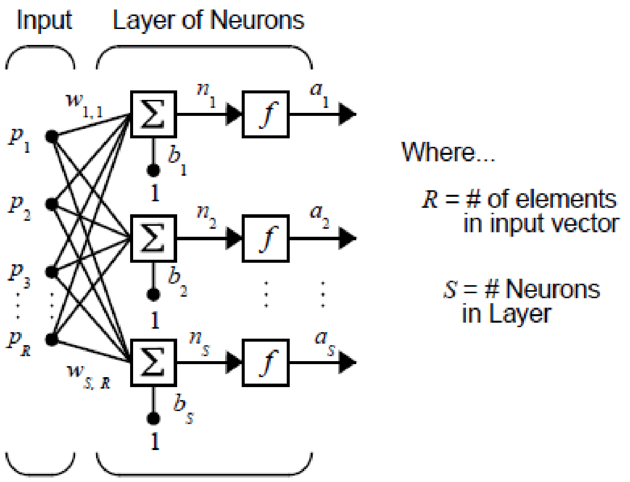
achieved. The output of the system at this stage is a colored segmented image.
The ANNSCIS (Adaptive Neural Network System for Color Image Segmentation) uses the HSV model for colour image segmentation. The adaptive thresholding block is responsible to find out the number of clusters and computation of multi-level sigmoid function for the neurons in the neural network. At every training epoch, the error is calculated by taking the difference between actual output and desired output of neuron. Here desired output of the neuron is its target value. Once the error calculated, it is back propagated to update the weights. The aim of neural network system is to minimize the error to obtain a segmented image. This training process continues until a minimum error is achieved. The output of the network is colored segmented image.
A one layer neural network with R input elements and S neurons are shown in Fig. 1.



.Fig. 1 Architecture of Neural Network

The latest trend in edge detection techniques is to use soft computing techniques and genetic algorithms. Many of the problems which occur by traditional methods of edge detection can be overcome by designing hybrids of fuzzy logic, neural network and genetic algorithms. Many GA- based segmentation tools of the edge detection like GENIE can also be used.

4.3 GENETIC ALGORITHM APPROACH

Genetic algorithms (GA) are random search algorithms based on the theory of biological evolution. These algorithms require an initial population of individuals, which are representatives of possible solutions of the problem being solved. The population evolves by transformations applied to its individuals while a fitness function is used to determine the strength of the elements in the population. The elements of the population are known as chromosomes and are represented by strings of bits. The fitness function is usually computed with basis on the values of those bits. An iteration of the algorithm is basically equivalent to a generation in the evolutionary process. [12]

Mainly, a genetic algorithm consists of three most important operations. They are Selection, Crossover and Mutation.

Selection: Fitness-proportional selection-The chromosome with minimum fitness value and another randomly chosen chromosome are selected from the parent pool to process crossover and mutation.

Crossover: The crossover recombines two individuals to have new ones which might be better.

Mutation: The mutation procedure introduces random changes in the population in order to steer the algorithm from local minimums that could prevent the discovery of the global solutions to the problem. [13]

V. PROPOSED ALGORITHM

The following steps of algorithm are used in order to find out the edges from grey scale or coloured images.

Step-1 Read an input binary or grey scale image whose edges are required to be found.
Step-II Add Gaussian noise to the input image
Step-III Select suitable value of standard deviation parameter in the Gausssian noise .
Step-IV Calculate mean square error (mse) between the original image and the noisy image by finding the square of the difference between original image and the noisy image.
Step- V Calculate the PSNR i.e. Peak Signal to noise ratio by the equation psnr_value = 10 * log10 (256^2 / mse)
Step-VI Apply any genetic algorithm to denoise the image.
Step-VII Apply feed forward algorithm in order to find the edges from the denoised image.
Step-VIII The final edge image will be the output image.

V. RESULTS AND DISCUSSION

The proposed algorithm has been applied to the various set of standard images and the edge images and the various parameters were computed. The results of various parameters computed on the different set of

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images are summarized in the form of the table 1 as shown below with noise at 10%.

INITIAL IMAGE

NOISY IMAGE

NOISE FREE IMAGE

EDGE IMAGE

The comparison of the values of the various parameter using the proposed algorithm are given in Table 1

Image type	PSNR	MSE	Noise Supp.
Lena Image	51.52	1.17	4.008
Sunset	33.44	0.20	1.19
Tree	52.78	0.15	2.25

Table 1 Comparison of proposed algorithm on different images.

CONCLUSION

In this paper, firstly we have reviewed the various techniques which are used for edge detection. One technique working well on one set of images might show poor results on other images. Hence no single set of algorithm shows good results. Hence in this paper we have proposed a new algorithm which uses combination of noising and denoising model, genetic algorithm and neural network. This shows improved results over the traditional set of algorithms used for edge detection. In future the results can be obtained by back propagation algorithm using neural network.

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